Radiation Tests at Los Alamos and CERN

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Motivation

Use Commercial of the Shelf electronics at the Liquid Argon Front end electronics, or elsewhere.

This would reduce the need for ASIC development and perhaps increase the range of options at the front end.

Main issue - single event effects. Ionizing dose or neutron damage are becoming a lesser concern.

Broader Impacts

1. It is the same problem found in Avionics and terrestrial applications (especially at high altitudes), e.g. FPGA based computers.

2. There are non-ATLAS (HEP) groups who are interested in our problem. One of them is CHREC.

3. There are HEP groups who are interested in our results for the very same reason: upgrade of their respective electronics at the LHC.

Strategy

1. Learn possible upset modes - the main issue here is Multiple Bit Upset (MBU) and Single Event Functional Interrupts (SEFI). SEFI is not Latch-up.

2. Implement mitigation techniques and develop redundant logic capable of handling MBUs and SEFI.

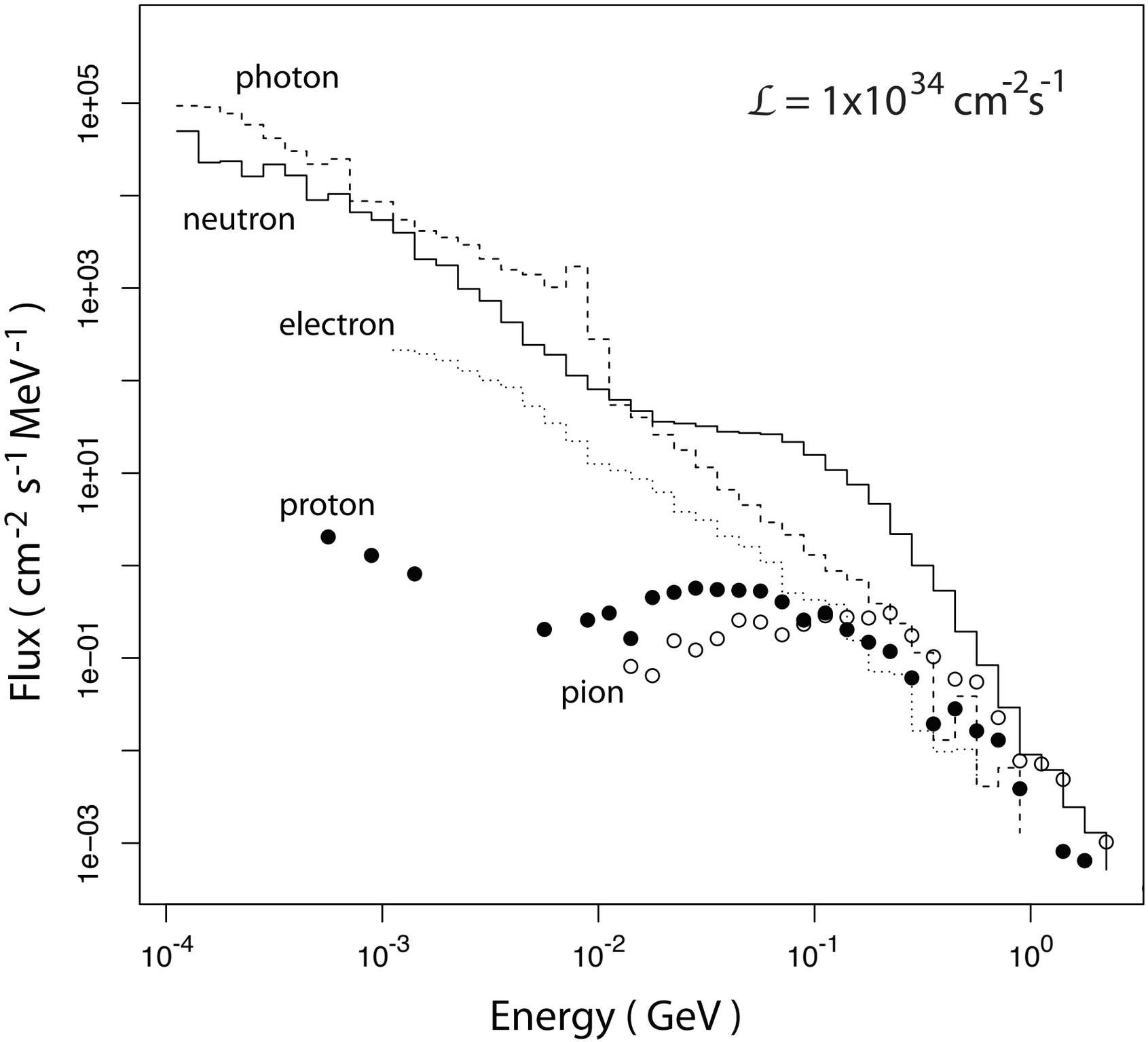
3. Test devices with mitigation in place.

How to get there

1. Test beams - Best performed with the background radiation as close as we will encounter when the detector is in operation.

2. Team up with groups who have experience in this type of activity, especially for complex devices such as FPGAs.

3. Work closely with manufacturers to obtain critical information on the device.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neutron
electron
proton
pion
$\mathcal{L} = 1x10^{34}\ cm^{-2}s^{-1}$
Flux ($cm^{-2}\ s^{-1}\ MeV^{-1}$)
1e+05
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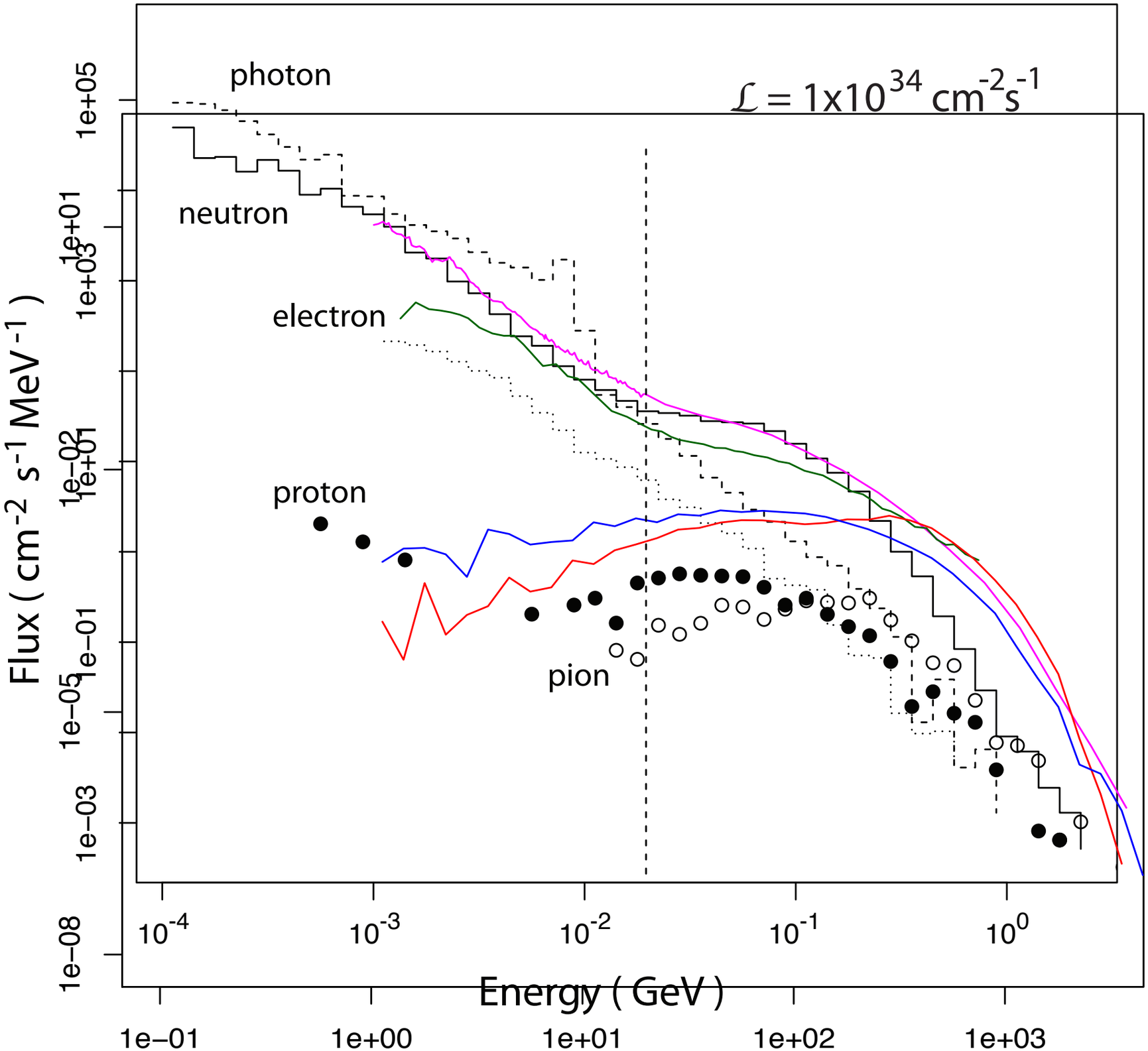
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^{0}
Energy (GeV)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Kintex-7, ADCs, Optical Links, and Power MOSFETs


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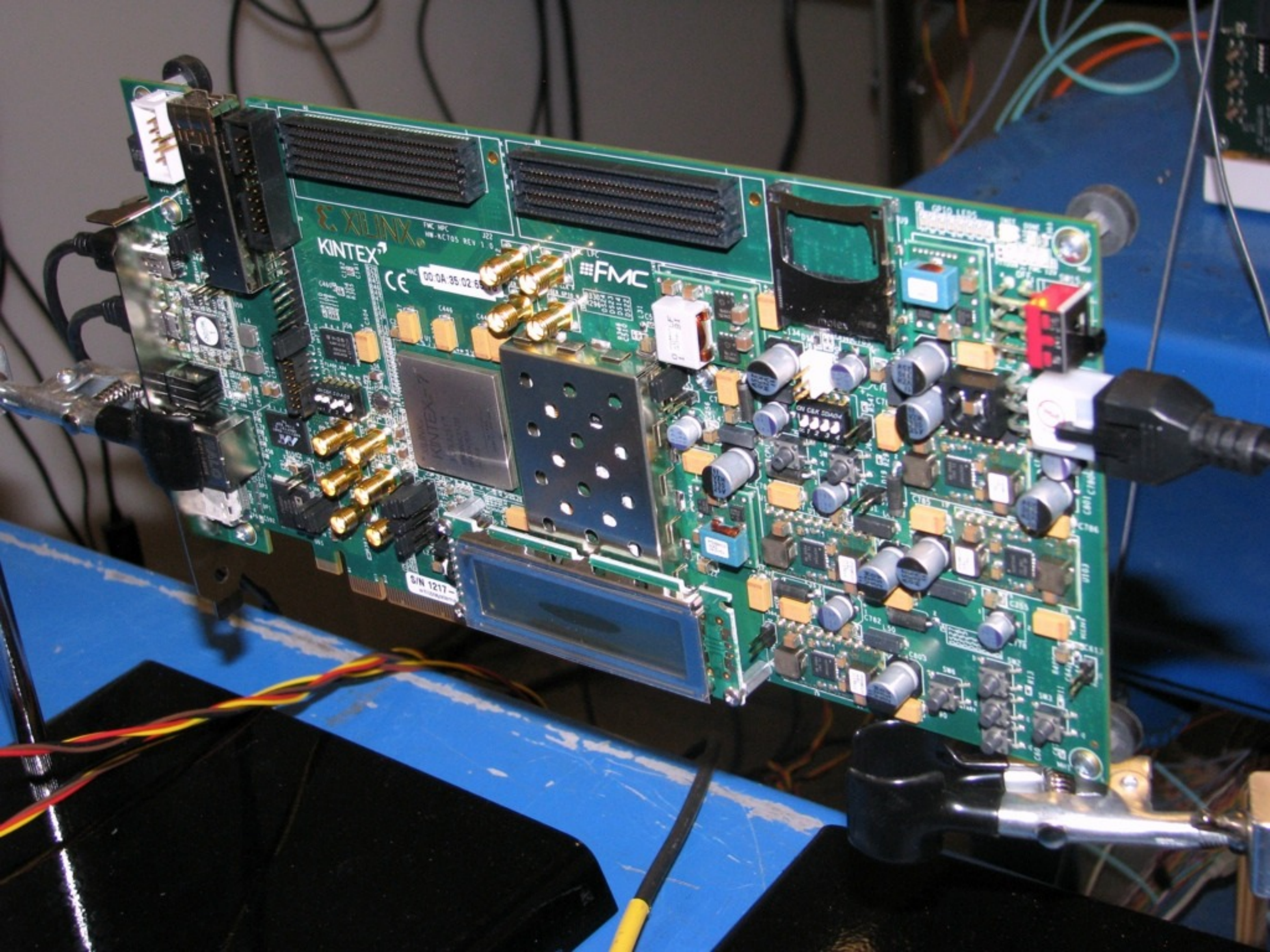
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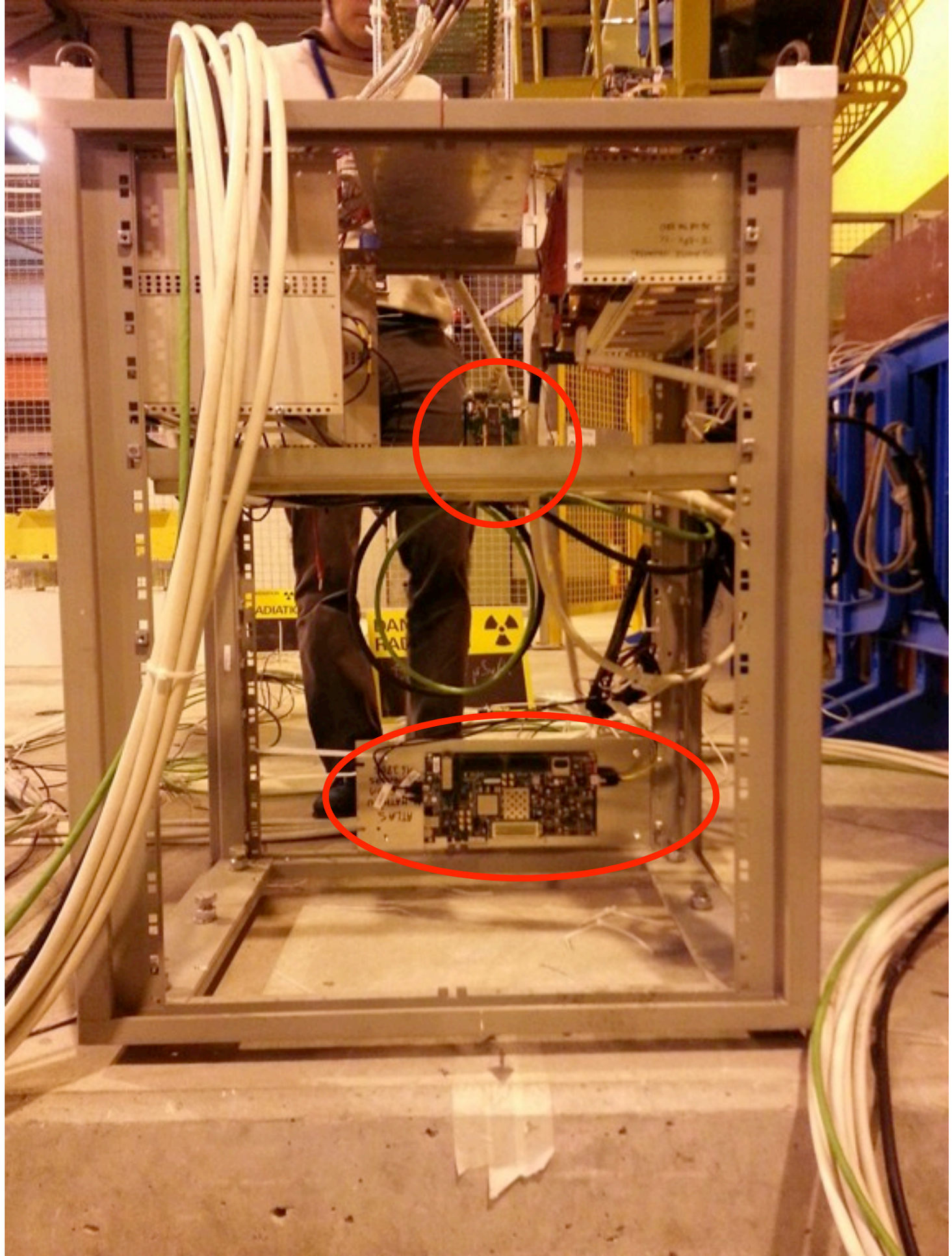
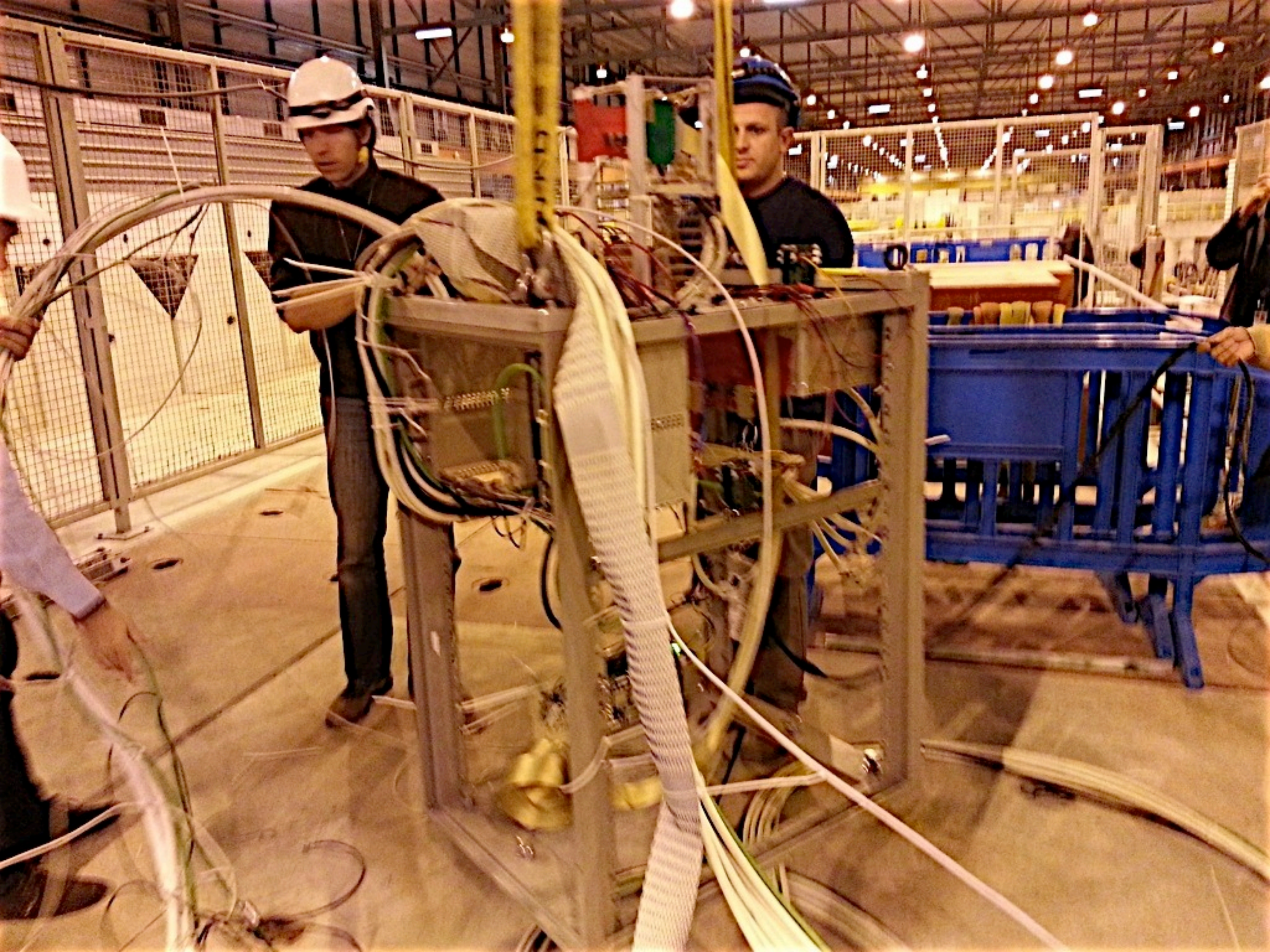
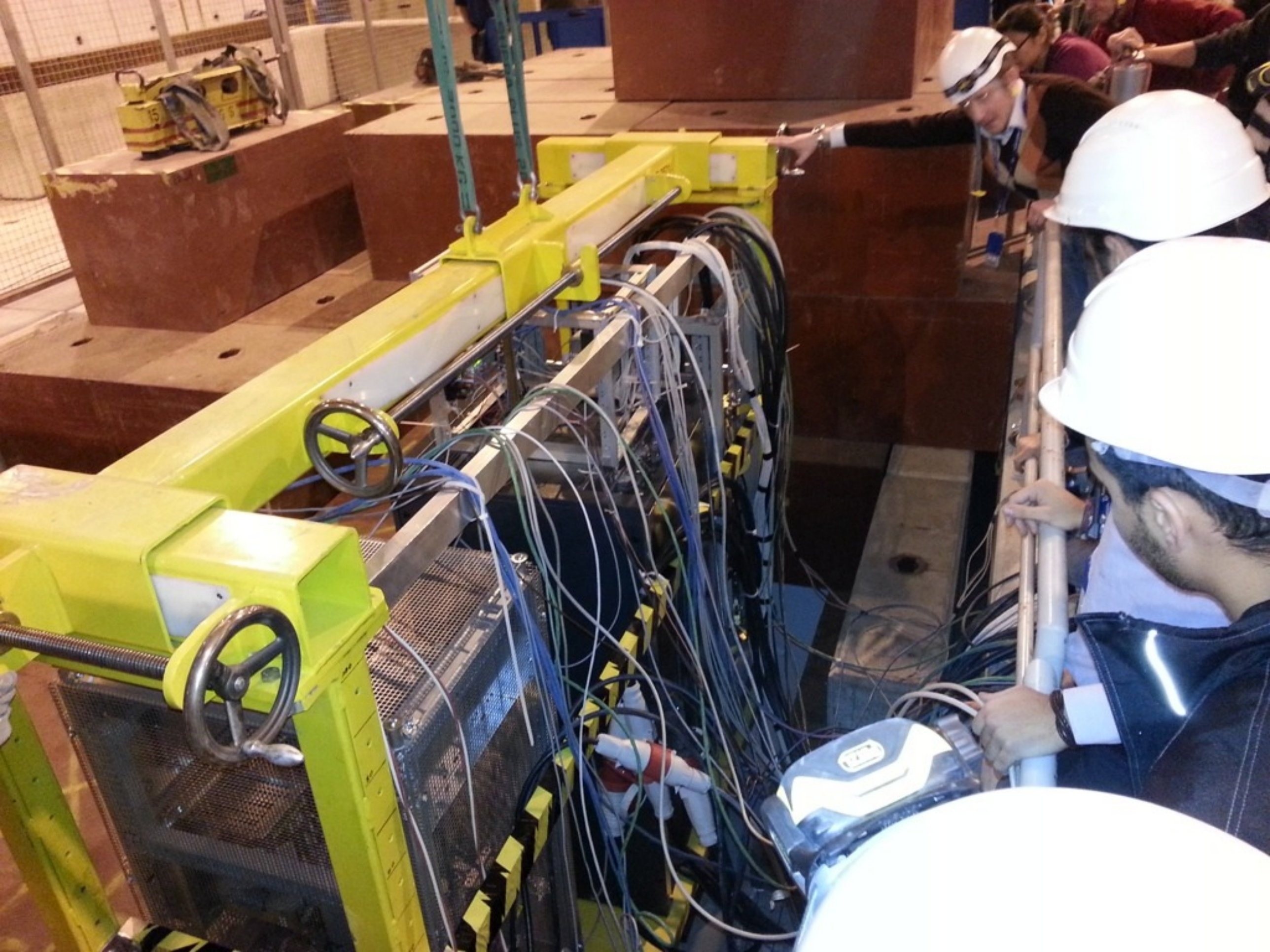







FIRE
CD GE 22-07


ALIMENTATION AC
CHANGEUR LASER

What we know so far

Plan for FPGA, is to evaluate cross sections and find different types of upsets, in particular multiple bit upset.

Los Alamos:

Kintex 7 - 6.27×10^{-7} cm^2/Device (± 16%)

ADC - $< 1 \times 10^{-11}$ cm^2

CERN (Preliminary): 1.19×10^{-6} cm^2/Device (± 30%)

Kintex 7 neutron energy threshold is ~ 3-4 MeV.

Lessons

It seems that the upset cross section at CERN is larger. This was also observed by teams testing memories. For higher energy packaging also becomes a factor.

One part of our data taking was done remotely. This might be a good way to collect data if CERN builds new test facilities at the PS.

Ground configuration and EM compatibility need to be understood as it may inject false SEU signals.

Next Steps

1. ADC: will be testing at Indiana with 200 MeV protons

2. Optical Links: Perhaps go back to Los Alamos

3: FPGA: develop mitigation techniques - We have developed a work plan.

4: Altera FPGA (Stratix V): We have a development board.

5. Medipix needs Calibration for high energy particles.

Facilities

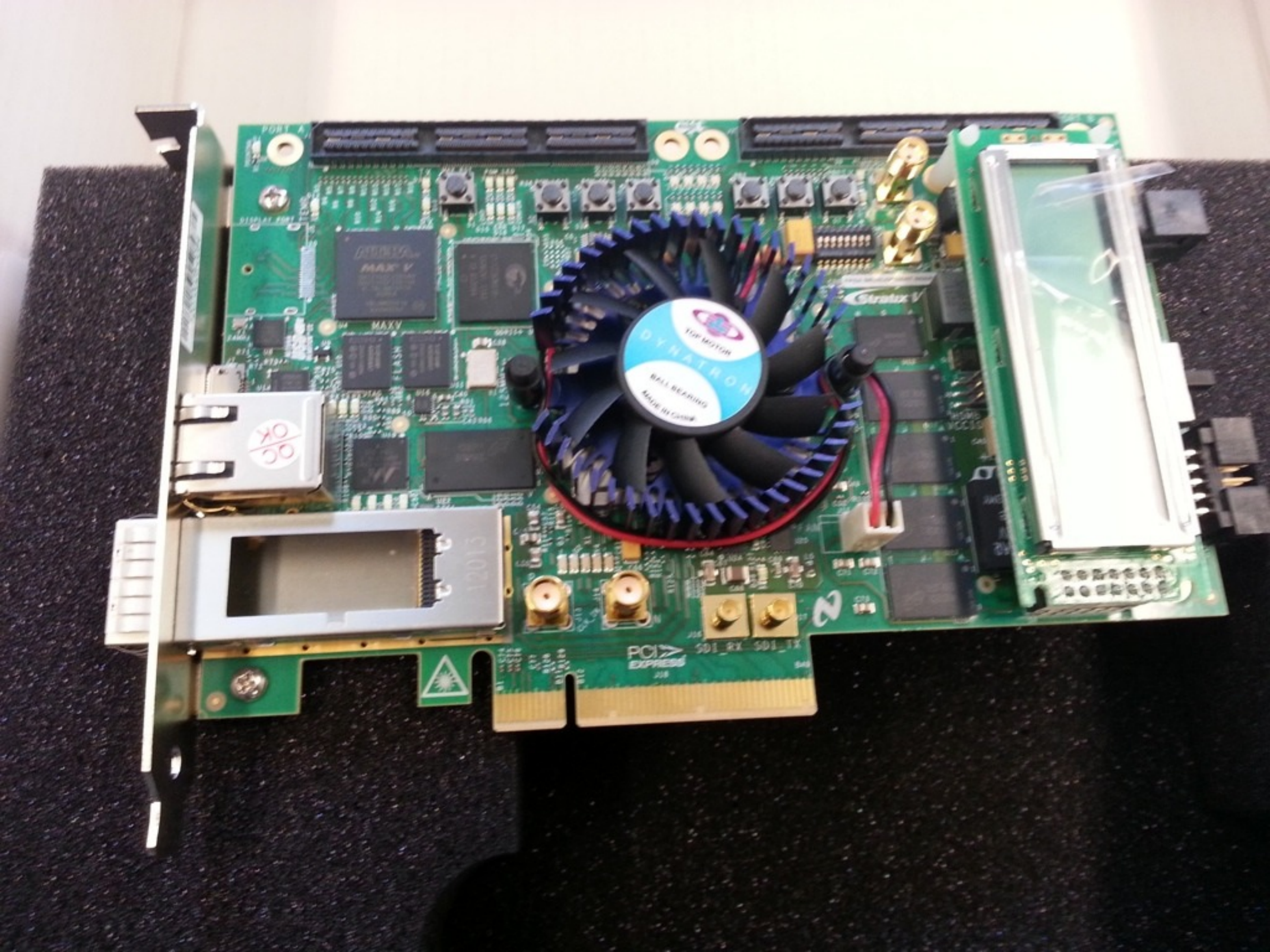
1. **LANSCE** (Los Alamos) - E_n < 800 MeV

2. **H4IRRAD** (CERN) - will shutdown with SPS. In 2014 a new facility will become available at the PS

3: Proton Facilities: **IUCF** (200 MeV) and **Mass General Hospital** (200 MeV), both cost ~ $650/hour. **TRIUMF** is another facility that could be used.

4: **Uppsala** - E_n < 200 MeV.

5. Other facilities?


MAX V
Stratix V
DYNATRON
PCI EXPRESS
SD1_RX
SD1_TX